NASSP Honours Project Proposal 2026

1. Level of the project:
Honours

2. Name of primary supervisor:
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3. Institution of supervisor:
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7. Project title:
Radio Luminosity Functions of Radio-Quiet Quasars with MIGHTEE and SDSS

Background and Motivation:

Radio observations provide a powerful and dust-unbiased view of the Universe, tracing both star formation in galaxies and accretion onto supermassive black holes. A small fraction of quasars are classified as radio-loud and produce powerful relativistic jets that can extend far beyond their host galaxies. However, the vast majority of quasars are classified as radio-quiet.

Despite their name, radio-quiet quasars still exhibit faint radio emission. The physical origin of this emission remains an open question in extragalactic astrophysics. One possibility is that the radio emission arises primarily from star formation in the host galaxy. Alternatively, the emission may be powered by processes associated with the Active Galactic Nucleus (AGN) itself, such as compact jets, accretion disk winds, or coronal activity near the black hole.

Understanding the origin of this faint radio emission is important for interpreting the faint radio sky and for understanding the connection between black hole growth and galaxy evolution.

One of the most powerful statistical tools used to study galaxy populations is the radio luminosity function (RLF). This function describes the number of sources per unit volume as a function of their radio luminosity. By studying how this distribution changes with redshift, we can gain insight into the dominant physical mechanisms responsible for radio emission in galaxies.

Project Aim:
The aim of this project is to construct the radio luminosity function of an optically selected sample of quasars and to investigate how the radio properties of these objects evolve with redshift.

Using deep radio observations from the MeerKAT International GHz Tiered Extragalactic Exploration (MIGHTEE) survey together with optical quasar catalogs from the Sloan Digital Sky Survey (SDSS), the student will construct RLFs for quasars. These luminosity functions will be used to explore the possible physical origin of radio emission in radio-quiet quasars.

Data:
The student will use multi-wavelength data across three extragalactic fields (COSMOS, XMM-LSS, and CDFS):

- **Radio Data:** 1.3 GHz radio continuum catalogs from MIGHTEE Data Release 1, which reach thermal noise levels of $< 2\,\mu$Jy beam^{-1}, allowing for the detection of extremely

faint radio emission.
- **Quasar Sample:** The sample will be drawn from the SDSS Data Release 16 Quasar catalog (DR16Q), which contains 750,414 spectroscopically confirmed quasars.

Methodology:
The student will:

1. **Cross-matching:** Perform positional cross-matches between the SDSS DR16Q optical catalog and the MIGHTEE radio catalogs to identify the radio-detected quasar population.
2. **Completeness & Selection Biases:** The SDSS quasar catalog has a well-defined optical magnitude limit determined by the survey selection criteria. In order to ensure a uniformly selected sample, a brightness cut will be applied to the quasar catalog based on the SDSS *i*-band magnitude limit. This step ensures that the quasar sample is approximately complete within the survey footprint. In addition, the radio sample is limited by the flux sensitivity of the MIGHTEE survey. Only radio sources above the catalog detection threshold will be included in the analysis. These optical and radio limits will be taken into account when constructing the radio luminosity function.
3. **Luminosity Function Calculation:** For quasars detected in the radio, intrinsic radio luminosities will be calculated using the measured radio flux densities together with the known redshifts of the quasars. The radio luminosity function will be constructed using the $1/V_{\text{max}}$ method and carefully constraining the accessible volume (V_{max}) by both the optical and radio detection limits.
4. **Evolutionary Modeling & Interpretation:** Fit the derived RLFs with standard models (e.g., double power-law) to evaluate the density and luminosity evolution across different redshift bins. The student will then compare these evolutionary trends to known star-forming and AGN population models to draw conclusions about the origin of the radio emission.

Expected Outcomes:
The project will produce derived RLFs for optically selected quasars reaching down to the faint $\sim 15\,\mu$Jy radio regime. The primary scientific outcome will be a quantitative assessment of how the RLF evolves, providing new constraints on whether star formation or AGN activity dominates the faint radio sky. The student will produce a comprehensive Honours thesis, with the potential for the results to contribute to a wider MIGHTEE collaboration publication.

Requirements:
The student must have basic programming skills in Python (specifically using packages such as `Astropy`, `NumPy`, and `Matplotlib`).